CLAIMS

We claim:

[c1] 1. In a wireless communication system, a method of establishing communication between a mobile and a base station using a ranging signal, the method comprising:

modulating, in the mobile station, ranging signals on at least one ranging subchannel:

wherein the ranging subchannel includes multiple subcarrier blocks;

wherein subcarriers in each subcarrier block are contiguous in frequency;

wherein ranging subchannels associated with the base station employ predetermined block configurations; and

a sequence of all modulating signals in a ranging subchannel is a ranging sequence;

estimating by the mobile station, using a received downlink signal from the base station, a path loss between the base station and the mobile station;

setting a power level of the ranging signals by an open-loop power control, wherein the mobile station adds a negative offset to the open-loop power setting to begin sending the ranging signal and gradually increases power as a number of failures and retries increases;

detecting, by the base station, a presence of the ranging signal, a time delay, and the power level, wherein the detection process comprises:

applying Fast Fourier Transform (FFT) to a selected window of the ranging signal;

correlating, in the frequency-domain, stored ranging sequences with the ranging signal, wherein the correlation is performed segment-wise, and wherein each segment of

the correlation is performed on the subcarrier block using a correlation result to detect and identify the ranging signal; and

correlating, in the time-domain, the identified ranging signal with a corresponding one of the stored ranging sequences, in a sliding-window fashion, to determine the time delay and power level of the ranging signal.

[c2] 2. The method of claim 1, wherein a total energy of a correlation of all segments identify a presence of the ranging signal.

[c3] 3. The method of claim 1, wherein detection is performed using a matched filter, correlator, or both, and wherein the base station performs a hierarchical detection, first in frequency-domain and then in time-domain.

[c4] 4. The method of claim 1, wherein if the ranging sequences are Hadamard sequences, dot-products of the ranging signal and a ranging sequence in a particular segment are simultaneously evaluated using a Fast Hadamard Transform (FHT).

[c5] 5. In a wireless communication system of cells, base stations, and mobile stations, a method of transmitting ranging signals by a mobile station to a base station for initiating a random access and establishing communication between the mobile station and the base station, wherein the base station uses the ranging signals to identify the mobile station, determine the mobile station's signal power, and measure the mobile station's time delay, the method comprising:

constructing ranging subchannels:

wherein a ranging subchannel includes at least one block having multiple subcarriers;

wherein the subcarriers in a block are contiguous in frequency; and

wherein power of a block is shaped by assigning different signal power levels to different subcarriers of the block;

assigning specific block configurations to ranging subchannels for each cell; and

transmitting binary or non-binary ranging signals over the ranging subchannels by modulating the subcarriers.

[c6] 6. The method of claim 5, wherein a signal power towards both frequency boundaries of a subcarrier block is lower than a signal power of subcarriers towards the center of the block.

[c7] 7. The method of claim 5, wherein a sequence of all modulating signals in a ranging subchannel is a ranging sequence, and wherein the blocks of a ranging subchannel are allocated so that the subchannel's autocorrelation in time-domain exhibits a set of specified properties.

[c8] 8. The method of claim 7, wherein a cell uses a specific subcarrier configuration for its ranging subchannels, and uses a specific set of ranging sequences.

[c9] 9. The method of claim 7, wherein the ranging subchannel blocks are distributed to provide minimum redundancy in a co-sampling function, or that spacing between the blocks of a ranging subchannel in the frequency-domain has no or minimum repetition.

[c10] 10. The method of claim 5, wherein a sequence of all modulating signals in a ranging subchannel is a ranging sequence, each segment of a ranging sequence is a Hadamard sequence, a full ranging sequence is composed of multiple Hadamard sequences, and wherein each segment corresponds to a block of contiguous subcarriers.

[c11] 11. The method of claim 5, wherein a sequence of modulating signals of a ranging subchannel, in time-domain, can be approximated by a binary sequence for reducing complexity of a receiver correlator, and wherein the ranging signal has low peak-to-average power ratio.

[c12] 12. In a network of base stations and remote stations, a remote station transmitter configured to transmit ranging signals for initiating communication with the base station, wherein the base station uses ranging signals to identify the remote station and determine at least one transmitter attribute, the transmitter comprising:

a facility for constructing ranging subchannels:

wherein a ranging subchannel comprises multiple subcarrier blocks;

wherein the subcarriers of a block are contiguous in frequency; and

wherein different power levels are assigned to different subcarriers of the block; and

a modulator for modulating binary or non-binary ranging signals on the subcarriers of the ranging subchannels.

[c13] 13. The transmitter of claim 12, wherein the power level towards high-end and low-end frequency boundaries of a subcarrier block is lower than the signal power of subcarriers towards the center of the block, or wherein the power level of the two subcarriers at both ends of a subcarrier block is zero.

[c14] 14. The transmitter of claim 12, wherein the base station uses a specific subcarrier configuration and employs a specific set of ranging signals to identify an association with the remote station.

[c15] 15. The transmitter of claim 12, wherein the subchannel blocks of the ranging subchannel are assigned for autocorrelation in time-domain.

[c16] 16. The transmitter of claim 12, wherein the subchannel blocks are distributed for minimum redundancy.

[c17] 17. The transmitter of claim 12, wherein a sequence of all modulating signals in a ranging subchannel is a ranging sequence, and each segment of the ranging sequence is a Hadamard sequence.

[c18] 18. The transmitter of claim 12, wherein a sequence of all modulating signals in a ranging subchannel is a ranging sequence, and wherein a time-domain signal corresponding to the ranging sequence is associated with a binary sequence, and wherein the ranging signal has low peak-to-average power ratio.

[c19] 19. A communication system performing random access for establishing communication between two stations, the system comprising:

at least one remote station estimating a path loss between itself and a base station by utilizing a received downlink signal from the base station, wherein the remote station sets power levels of a ranging signal by adding a negative offset to the power setting at the beginning of a signal transmission and gradually increases power as a function of a number of random access failures and retries; and

at least one base station detecting a presence of each ranging signal, the ranging signal time delay, and the ranging signal power level, wherein:

the base station performs hierarchical detection, in frequency-domain and in time-domain, when the ranging signal is modulated on subcarriers of a ranging subchannel and the ranging subchannel is composed of blocks of contiguous subcarriers; and

the detection process comprises:

applying Fast Fourier Transform (FFT) to a selected window of a received signal;

correlating, in the frequency-domain, the base-station-specific ranging sequences with a received signal:

wherein the correlation is performed segment-wise;

wherein each segment of the correlation is performed on a subcarrier block; and

wherein the correlation result identifies a ranging signal; and

correlating, in the time-domain, a full sequence of the identified ranging signal with the corresponding base-station-specific ranging sequence, in a sliding-window fashion, to find the ranging signal time-delay and power.

[c20] 20. The system of claim 19, wherein a sequence of all modulating signals in a ranging subchannel is a ranging sequence and if a ranging sequence is composed of Hadamard sequences, a dot-product of the received signal and the ranging sequence in a particular segment can simultaneously be evaluated using a Fast Hadamard Transform (FHT).

[c21] 21. The system of claim 19, wherein a given received ranging subchannel, $\{\vec{r}(k)\}_{k=1}^{K}$, is correlated in the frequency-domain with the ranging sequences associated with the base station, segment-wise, where K is the number of blocks in a ranging subchannel, and wherein if the m^{th} sequence is denoted by $\{\vec{b}_m(k)\}_{k=1}^{K}$, the correlation value, P_m, is computed by:

$$P_m = \sum_{k=1}^{K} \left| \left\langle \vec{r}(k) \bullet \vec{b}_m(k) \right\rangle \right|^2 ,$$

where the dot-product is computed by:

$$\left\langle \vec{r}(k) \bullet \vec{b}_m(k) \right\rangle = \sum_{n=1}^{N} x(k,n) \cdot \left[c_m(k,n)\right]^*$$

and where N denotes the number of subcarriers in a block, $x(k,n)$ denotes the received version of the n^{th} subcarrier of the k^{th} block in the given ranging subchannel, and $c_m(k,n)$ represents the value of the n^{th} subcarrier of the k^{th} block in the given ranging subchannel for the m^{th} sequence, and wherein a P_m greater than a given threshold indicates that a ranging signal corresponding to the m^{th} sequence has been detected.

[c22] The system of claim 19, wherein the time-domain correlation of a full sequence of the identified ranging signal is performed, in a sliding-window fashion, to find the time delay of the ranging signal, using:

$$C(\tau)=\left|\sum_{t=0}^{T} s(t+\tau)\cdot z^{*}(t)\right| \qquad \text{for } \tau=0,1,\cdots,D$$

where T denotes the length of the time-domain ranging sequence, D corresponds to a maximum time delay allowed by the system, and $z^{*}(t)$ represents the time-domain signal of the detected ranging sequence, and wherein the maximum value of $C(\tau)$ for $\tau=0,1,\cdots,D$ is an estimate of the ranging signal power and the corresponding value of τ indicates the ranging signal time-delay.

[c23] 23. In a wireless communication system of geographic cells that include a first and second station, an apparatus for transmitting random access originating signals from the second station to the first station for establishing communication with the first station, wherein the first station uses the ranging signals to identify the second station and determine at least the first station's power or time delay, the apparatus comprising:

a transmitter at the second station producing sets of carrier groups:

wherein the first station employs a specific carrier configuration for the sets of carrier groups;

wherein a set of carrier groups comprises multiple carrier groups ;

wherein the carriers in a group are substantially contiguous; and

wherein binary or non-binary ranging signals are modulated on carriers of the set of carrier groups.

[c24] 24. The apparatus of claim 23, wherein power levels of the carriers within a group are manipulated to avoid interference with other carrier groups.

[c25] 25. The apparatus of claim 23, wherein the first station is a base station and the second station is a mobile station, and wherein a cell is configured to have a specific set of carrier groups and use a specific set of ranging signals to identify a mobile station within its coverage.

[c26] 26. In a communication system including a first station and a second station, a random access method of initiating communication with the first station, the method comprising:

means, in the second station, for estimating path loss between the first station and the second station, using a received signal from the first station;

means for setting power levels of a ranging signal, at the second station, based on a number of random access failures and retries; and

means for detecting, by the first station, a ranging signal, a time-delay and the power level of the ranging signal, wherein the detection method comprises:

- means for applying Fast Fourier Transform (FFT) to a selected segment of a received signal;
- means for segment-wise correlating ranging sequences of the first station with a received signal, in the frequency domain, and detecting the ranging signal; and
- means for performing a time-domain correlation of the ranging signal's full sequence and a corresponding ranging sequence of the first station, to find the ranging signal time-delay and power.

[c27] 27. The method of claim 26, wherein the first station is a base station and the second station is a remote station, and wherein if ranging sequences are Hadamard sequences, a dot-product of the received signal and the ranging sequence in a particular segment can simultaneously be evaluated using a Fast Hadamard Transform (FHT).